Space Weather Technical Forecast

Issued on Monday, 29 July 2024 at 13:22 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrivals expected day 1 or early day 2 (29-30 Jul), and then again day 3 into day 4 (31 Jul-01 Aug). G1-G2 / Minor to Moderate Storms, with a chance G3 Strong Storms. Moderate to High solar activity.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with an impulsive X1.5 flare at 29/0237 UTC from AR3766 in the south-centre disc, and occasional small M-flares. This is in the centre of region of a cluster of sunspots in the south-centre disc, with a moderate strength delta spot on its leader. Large but simpler regions AR3765 and AR3767 are to the south of the cluster, however due to their proximity some merging is likely, leading to further increased complexity. Other regions of note include AR3670 in the north-centre disc, which after rapidly emerging on 28 Jul, is now maturing but also developing some complexity on its northern most intermediate spots, with another delta configuration forming. While to the southwest disc, AR3762 and AR3768, while showing some decline, also contain small delta-spots, and have a history of producing flares that produce CMEs. There are ten active regions currently on the disc.

A number of CMEs were observed in imagery, with the partial halo CME from off the southwest-disc assessed as being Earth-directed. This has been attributed to a combination of the M2.6 of AR3767 at 1250 UTC and the long period M1.7 flare from AR3768.

Solar Wind / Geomagnetic Activity: Slow wind conditions persisted through the period. Solar winds speeds, as measured by ACE at L1, declined slightly from around 400 km/s to near 350 km/s. Density was below average. Interplanetary magnetic field, Bt, was weak 4-6nT, with north-south component, Bz, variable in the range +4nT to -6nT. Phi angle was predominately positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 is at background levels. High energy electron flux (greater than 2MeV) observed at GOES16 was at background to moderate levels. The 24-hour fluence was below the Active threshold. 7.44e6 integrated pfu was observed at 29/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is expected with further M-class flares expected and chance of isolated X-class flares.

Solar Wind /Geomagnetic Activity: A number of CMEs are expected to arrive through the period. The first is expected later on day 1 or early day 2 (29-30 Jul), originating from an M-class flare on 27 Jul, but potentially combining a further weak filament. The CMEs from the M9.9 early on 28 Jul, and then the M2.6 and long period M1.7 later on 28 Jul are then expected to arrive late day 2- day 34 (30-31 Jul), perhaps combining into a single arrival, although this is currently low confidence. Overall, initially Quiet conditions are likely to increase to G1-G2 Minor Storm with any CME arrival with a slight chance of G3 Strong storms. This risk continues through the period.

Energetic Particles / Solar Radiation: High energy proton flux is currently at background. Should any notable flares occur there is a likelihood of this increasing above background, with a

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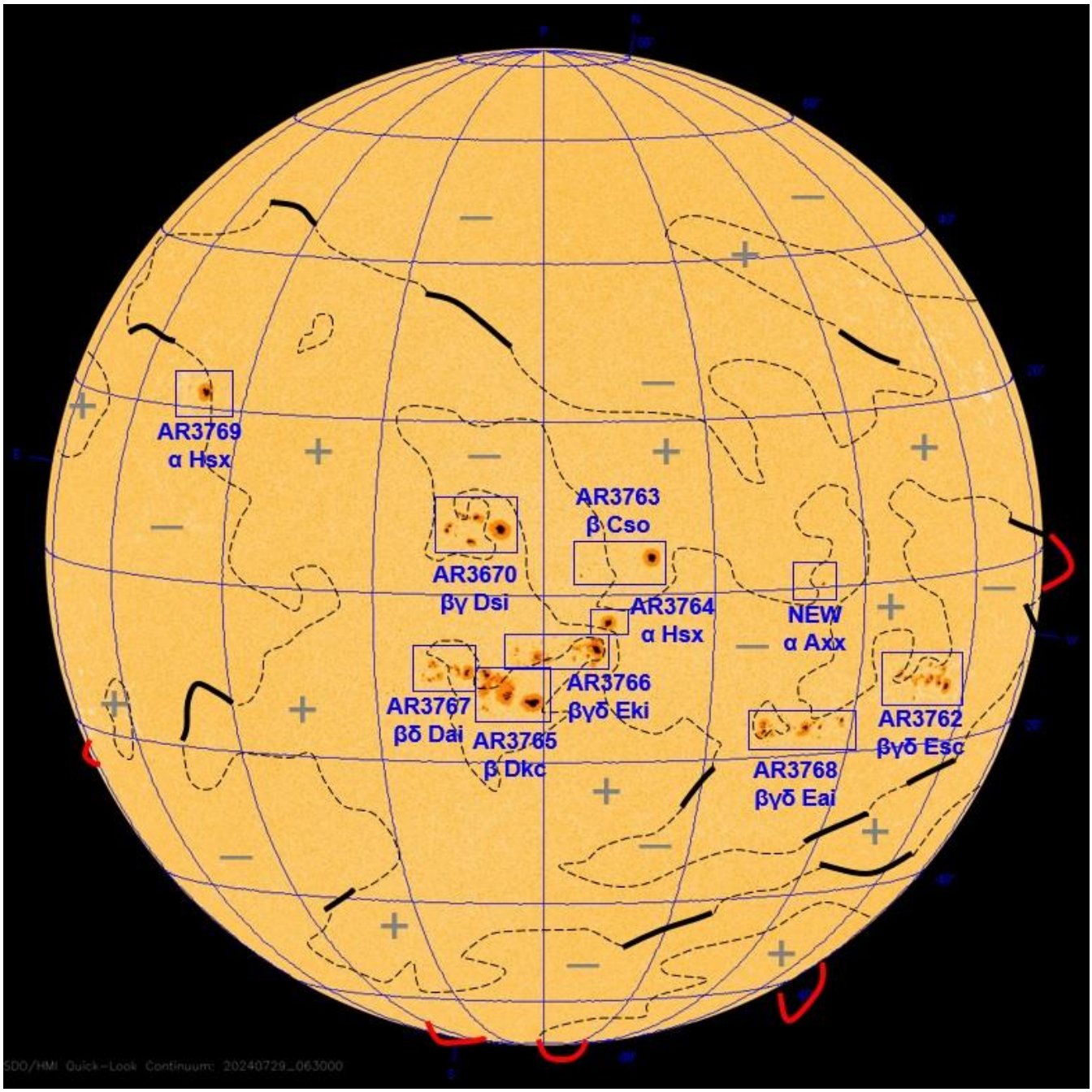
slight chance of exceeding the S1/Minor Storm threshold. This is due to the increasingly geoeffective location of the sunspot regions on the disc. The high energy electron flux is forecast to be mostly at background levels. The associated 24-hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Figure 1. Solar Analysis Valid 29/0800 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are number of Earth-directed CMEs that are expected to arrive through this period.

The CME from the M3.1 flare of AR3762 on 27 Jul is anticipated to arrive later on day 1 or early day 2 (29-30 Jul). This is only moderate confidence due to difficult analysis with overlapping CMEs in imagery, including a notable far-side event. However the CME is likely to also cannibalise a weak filament eruption off the southeast disc that occurred on 26 Jul, leading to the potential for a stronger arrival. Elevated solar winds, with G1-G2 Minor to Moderate storms are likely, with a chance of isolated G3 Strong Storms.

There are two further CMEs of note. The first from the M9.9 from AR3764 on 28/0157 UTC, and the second from the combination of the M2.6 at 28/1250UTC from AR3767 and the LP M1.7 at 28/1422 UTC from AR3768, off the southwest disc. These are then expected to arrive late day 2 or day 3 (30 Jul-31-Jul), with a chance of these also combining into a single stronger arrival event, or being in fairly short succession. These are both complex eruptions, with reduced confidence due to limited STEREO A imagery, alongside further not-Earth directed CMEs contaminating imagery. These also give a chance of elevated solar winds with G1G2 Minor to Moderate storms and a slight chance of isolated G3 strong storms.

Aside from the CMEs, there are no further sources of enhancement expected, with initially Quiet slow wind conditions until the first arrival. After this, the CME influence is expected to dominate.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	60	60	60	30
Strong	G3	No	20	20	20	5
Severe	G4	No	5	5	5	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0200	Nil	Filament	10E 24S	600 km/s	29/1500 -6+9 hrs	Likely absorbed into CME below
27/1100	Asymmetric Full	M3.1 AR3762	08W 15N	870 km/s	29/1500 -6+9 hrs	Low confidence with far-side contamination
28/0808	Asymmetric Full	M9.9 AR3764	03 W 04 S	598 km/s	31/0200 -6 +12hrs	Likely combining with below
28/1838	Partial	M2.6 AR3767 M1.7 AR3768	18W 08 S	747 km/s	31/0200 -6 +12hrs	Complex analysis. Combines with above.

Figure 2: Enlil and Ensemble. Two main arrivals, despite four CMEs.

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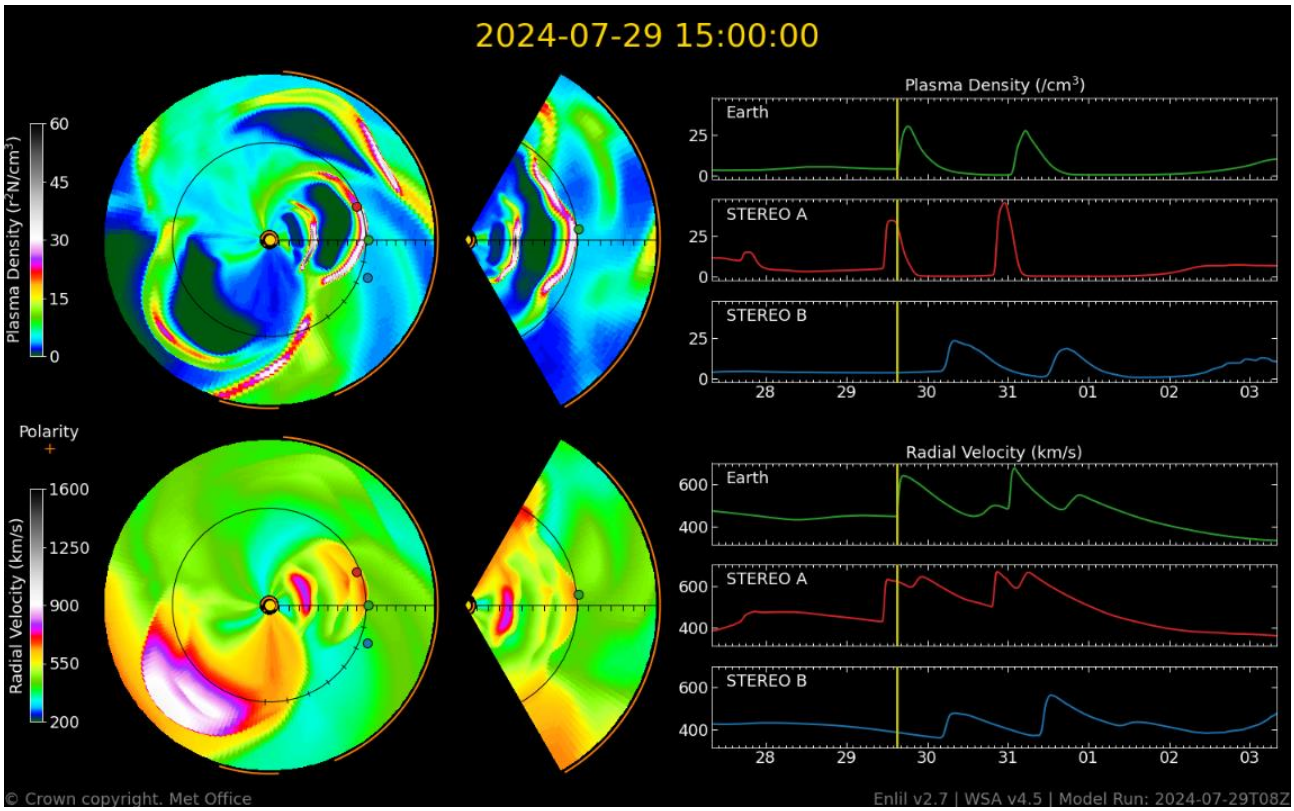

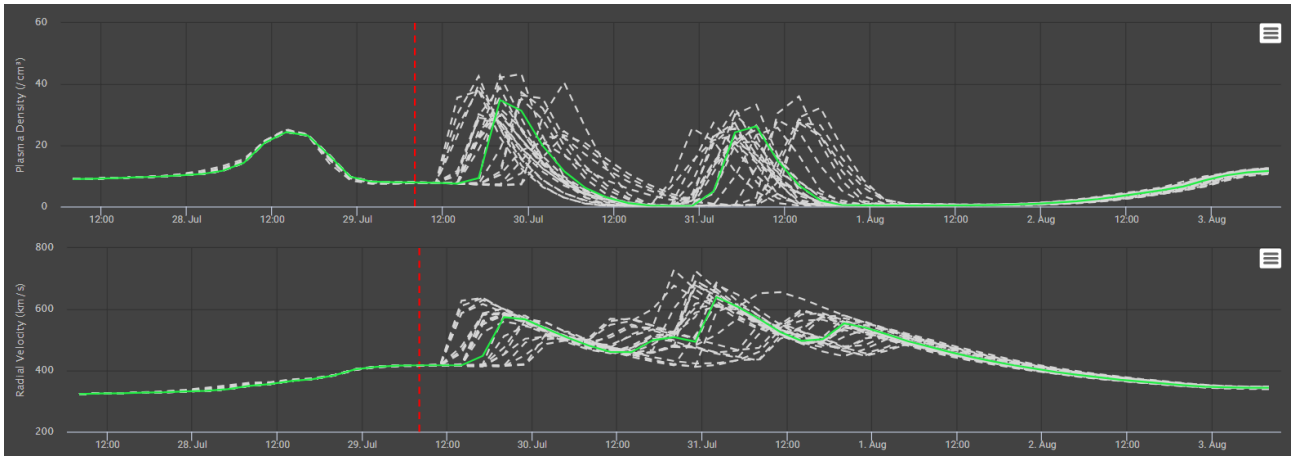

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Radio Blackouts - X-Ray Flares:

High to Moderate activity is forecast, with M-class flares expected and a chance of isolated X-class flares.

There are ten regions currently on the Earth-facing Sun with a number of moderately sized and complex regions. AR3762, near the southwest limb has been showing some signs of decline, but maintains a small delta spot within its intermediate region. This is followed by AR3768, which also has a small delta spot. A broad cluster of regions is then situated in the centre disc, including AR3766, the source of the most recent X-class flare. This region has a clear delta configuration to the north of its main leader, with some ongoing growth. AR3765 and AR3767 are across the southernmost portion of this cluster, and with the two regions showing some slight ongoing growth but also some sign of merging and increasing complexification. AR3770 in in the north-centre disc also rapidly developed in the last 24-48 hrs, although this growth has largely slowed, further development is likely.

Alongside the regions on the disc, there is the potential for a very active region to rotate onto the Earth-facing disc day 2 (30 Jul), the likely source of a couple of notable far-sided CMEs, with strong X-class flare activity also detected by the Solar Orbiter spacecraft. However, this is low confidence.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	80	80
Very Active	R3 to R5 X Class	Yes	20	20	20	20

Figure 3a: GOES 16/18 X-ray Flux)

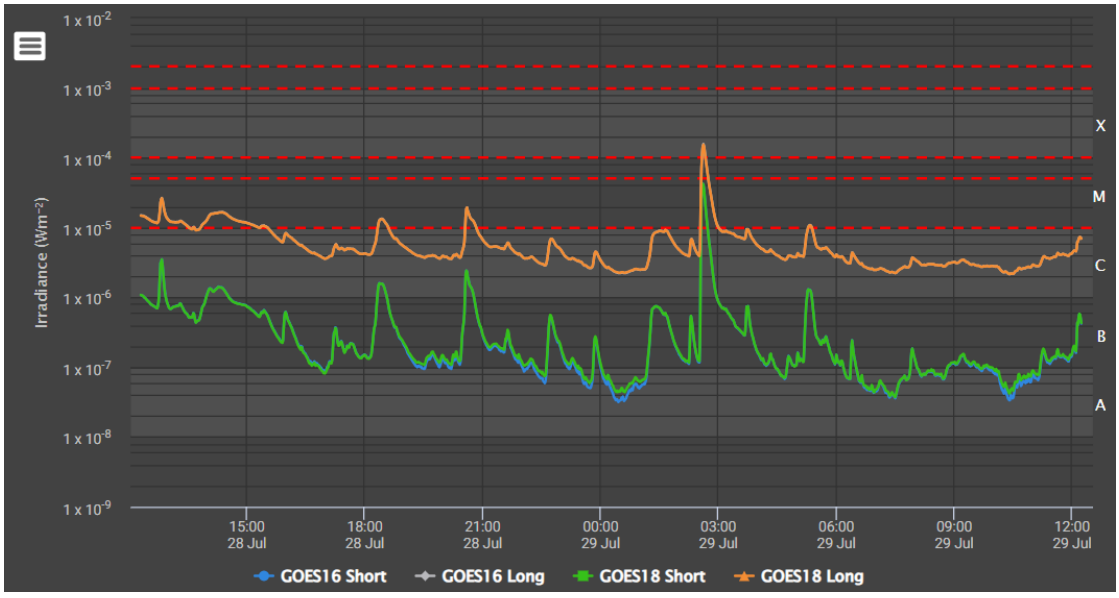

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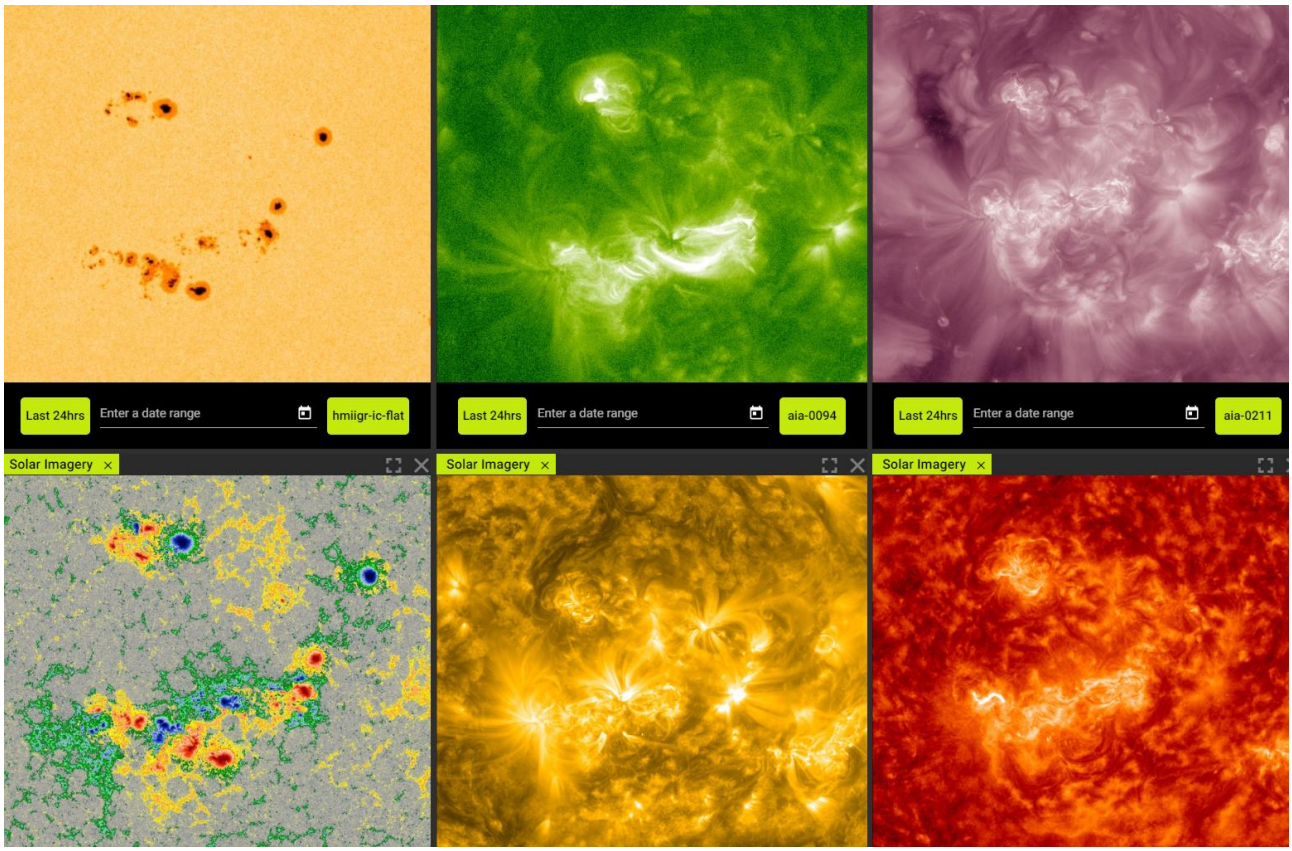
Figure 3b: SDO Imagery of central disc sunspot complex



Solar Radiation Storms - (High Energy Protons):

High energy proton flux, as observed by GOES-18 is currently is currently at background but has the potential to see small rises in response to any notable flares on the disc, with a number of moderately sized and complex sunspots moving into the southwestern quadrant. This bring a slight chance of reaching the S1 Minor Radiation Storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16, is expected to be at background levels for much of the period. Recent fast wind enhancement did bring a small enhancement to Moderate levels at diurnal peak, however CME arrivals anticipated on days 1-3 (29-31 Jul) are likely to cause the observed flux at GEO to decline to background. There is some potential for a slight recovery as any CME influence recedes, however this is very low confidence, with mainly background levels most likely to persist

The associated 24 hr electron fluence is expected to remain below the Active level. Due to the expected CME arrivals MOSWOC REFM is likely to be variable in effectiveness, but providing good guidance until these occur.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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